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Golden rule of forecasting rearticulated: Forecast unto others as you would have them forecast unto you

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ABSTRACT

The Golden Rule of Forecasting is a general rule that applies to all forecasting problems. The Rule was developed using logic and was tested against evidence from previously published comparison studies. The evidence suggests that a single violation of the Golden Rule is likely to increase forecast error by 44%. Some commentators argue that the Rule is not generally applicable, but do not challenge the logic or evidence provided. While further research might provide useful findings, available evidence justifies adopting the Rule now. People with no prior training in forecasting can obtain the substantial benefits of following the Golden Rule by using the Checklist to identify biased and unscientific forecasts at little cost.

1. Introduction

In our article (Armstrong, Green & Graefe, 2015-in this issue), we propose the Golden Rule of Forecasting—"the Golden Rule" hereafter—as a unifying forecasting theory. The theory asserts that conservative forecasts will be less biased and more accurate than those that are not conservative. A conservative forecast is one that draws upon, and is consistent with, all relevant and important knowledge about the situation and forecasting methods. Operational guidelines are provided to help forecasters implement the Golden Rule and to help forecast users to assess the validity of forecasts.

Proposing a simple unifying theory for the broad and diverse field of forecasting is both ambitious and controversial, so challenges to the theory are expected and welcome. To that end, we are fortunate to have published, along with our article, four thoughtful commentaries from leading forecasting researchers. In addition, the commentators provided suggestions that led to major improvements in the article.

2. Fildes and Petropoulos

In two applications that they describe, Fildes and Petropoulos (2015-in this issue; henceforth F&P) suggest that following the Golden Rule may have produced less accurate forecasts than those obtained in contravention of the Golden Rule. F&P ask whether following the Golden Rule might lead to rejection of "a well-performing method" that has been validated for a given situation. Our answer is that the Golden Rule requires a priori analysis of the conditions of the forecasting problem. The method selection procedure F&P suggest is in accordance with many of the Golden Rule guidelines. For example, damped trend forecasting using de-seasonalized data—F&P's DDamped—satisfies most of the relevant Golden Rule checklist items. DDamped also performed best of all the methods that F&P tested and provided forecasts that were more accurate than the next-best method—ARIMA—for all eight of the classifications of time series by characteristics—segments—that F&P examined.

While F&P's examples favor the Golden Rule, following the Golden Rule may not improve forecast accuracy for every forecasting problem. One can, however, *expect* improvement by doing so. The Golden Rule article provides only a first step in the development of evidence-based guidelines for conservative forecasting: other guidelines and conditions are surely possible.

F&P are right that further research could contribute useful evidence for guidelines that currently lack evidence. In addition, further research might lead to more effective ways to state the guidelines, and to the identification of the conditions under which the guidelines are most effective.

F&P suggest additional studies that are relevant to the Golden Rule. In particular, they suggest Ord and Fildes (2013) in testing guideline 4.2. The suggestion is reasonable. Inclusion would change the papers-

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for-versus-papers-against score from 102-to-3 to 102-to-4. We expect that there are other relevant studies that are missing from the Golden Rule article. Readers who are aware of omissions are welcome to forward their suggestions for posting on GoldenRuleofForecasting.com.

F&P are also concerned with aspects of the guidelines on causal modeling, such as the recommendation to use all variables that are important, which they regard as conflicting with the thrust of the article, and this Special Issue, towards simplicity. While some researchers have suggested that more variables means more complex, our article argues that the number of variables alone does not make for complexity. The Golden Rule Checklist provides guidance on how to make use of knowledge on many variables in simple ways, and to thereby avoid complexity.

On the topic of causal methods, F&P mention research on principal components—indexes based on correlations among predictor variables—by Stock and Watson (2002). At first glance, this approach might seem conservative in that it includes more information, which is in line with Golden Rule Guideline 4.3. The approach, however, employs statistical rules rather than causal knowledge and thus, uses *less* prior knowledge—which violates the Golden Rule. Consistent with this, eight empirical comparisons found that the principal components method harmed forecast accuracy (Armstrong, 1985, pp. 223–225, 518, 580, 610, 628–629). The reasons Stock and Watson's findings differ from other research on principal components are unclear. We contacted the authors on two occasions, but were unable to clarify: (1) whether their forecasts were ex ante, (2) whether they used successive updating, (3) the number of forecasts in their ex ante test, (4) how the principal components were forecasted, (5) why they omitted such competitive methods as equal-weights regression using all of the variables incorporated in the principal components, or regression analyses using variables based only on theory, and (6) why they used the mean square error, which had long been shown to be unreliable for comparing forecasting methods (Armstrong & Collopy, 1992).

F&P are right to be disappointed with the failure of software providers to include evidence-based forecasting procedures. Imagine the losses to the economy that flow from poor sales forecasting. The situation might change if software users request that software providers follow the Golden Rule.

3. Goodwin

Goodwin (in this issue) is skeptical about the possibility of identifying a simple unifying theory for the field of forecasting. Moreover, he suggests that the term "conservative" does not properly describe the nature of the 28 Golden Rule guidelines.

Goodwin does not suggest an alternative term, however. The use of the term "conservative" in the Golden Rule article does differ somewhat from that of the *Oxford English Dictionary*, though it is consistent with at least some common usages of the term. Specifically, conservative is used in the Golden Rule in the sense of adhering to cumulative knowledge. Thus, following the Golden Rule helps to avoid conjecture and bias. Goodwin's commentary nevertheless inspired an alternative description for the Golden Rule, which became part of the title of this response: "Forecast unto others as you would have them forecast unto you."

Goodwin is correct on the need for decision-makers to consider the costs and benefits of implementing the various guidelines. Most of the guidelines should be inexpensive to implement. Some, however, are not; especially the need to conduct a priori analyses to identify all important knowledge. In other words, decision makers should consider what the marginal net benefit of increased forecast accuracy is for the problem at hand.

Goodwin suggests that further research should be done on the Golden Rule, especially with respect to whether the Golden Rule applies to the estimates of prediction intervals and to forecasts in the form of probability distributions. These suggestions are sensible, as is his suggestion that more research would help by providing more evidence on the specific conditions under which the Golden Rule is—and is not—effective in reducing forecast error.

4. Soyer and Hogarth

Soyer and Hogarth (2015-in this issue, henceforth S&H) suggest that there are several problems that might hinder the use of the Golden Rule. One problem, they suggest, is that the checklist does not provide sufficiently simple and specific instructions to be useful in practice. To illustrate their point they refer to item 1.1: "Use all important knowledge and information." That item is *not*, however, one of the guidelines—it is a heading for Guidelines 1.1.1 and 1.1.2 provided to show users the general organization of the guidelines. Nevertheless, they make a fair point that further study would help to improve the description of the guidelines.

Another problem S&H propose is that some of the guidelines would be overly burdensome to follow in practice, particularly the requirement to include all important variables. Doing so involves using systematic and unbiased procedures to search the literature, and to obtain information from heterogeneous experts. While the cost of following the guidance can be high, the cost of *not* following it is likely to be *much* higher for important projects. If forecasters choose to omit important information, they should fully disclose what was omitted and explain why. For example, the Club of Rome's 1972 *The Limits to Growth* report employed a model with 1,000 equations to forecast that natural resources would soon run out. Economists were quick to suggest that it would have been helpful if the forecasters had included the prices of resources in their model. Had they done so, their forecasts would not have been alarming—nor would they have provided the basis for one of the best-selling environmentalist books in history.

S&H's interpretation of research on the one-reason heuristic, which involves predicting by using only the most important variable, is arguable. The heuristic provides a good forecast *if* the forecaster knows which causal variable will be most important over the forecast horizon, and *if* that variable's effect exceeds that of all other variables combined. These conditions are consistent with the Golden Rule, since the forecaster needs to have complete information about which variables are important, and about the magnitudes of their effects.

One way to test the one-reason heuristic would be to compare its forecasts with those from the index method. The index method involves obtaining evidence on causal factors by a priori analysis. That is, the index method draws upon outside evidence, especially experimental evidence, and does not estimate relationships from the data at hand. Thus, the index method allows forecasters to use as many variables as theory and evidence show to be important.

The ongoing efforts of S&H to improve ways of communicating forecasts so as to help users interpret them are admirable. As their research shows, even leading experts in econometrics have difficulty in interpreting the outputs from basic regression analyses (Soyer & Hogarth, 2012).

As S&H suggest, when forecasters fail to forecast improbable events, the consequences for forecast users can be dire. Forecasts from regression analysis are susceptible to that risk because regression models tend to exclude important variables due to lack of data and to lack of historical variation in the some causal variables. Using the index method instead reduces the risk of failing to forecast an improbable outcome by including information about all factors that are known to be important.

The proper role of a forecaster is to provide decision makers with expected values and confidence intervals for relevant costs and benefits. In turn, rational decision makers should avoid making judgmental adjustments based on their opinions about what unusual things might happen. Indeed, based on the research to date, judgmental adjustments of objective forecasts are likely to harm forecast accuracy (Armstrong et al.,2015-in this issue, Golden Rule checklist item 6).

5. Gardner

Gardner (in this issue) discusses the slow adoption of the evidence-based forecasting technique of damping. The extensive evidence on the value of damping has been largely ignored in practice, despite the clarity of Gardner's writing and his efforts to ensure that the methods are freely available.

Gardner's research on trend damping represents one of the most important contributions to extrapolation methods. Gardner expresses reservations, however, about three of the Golden Rule guidelines that are intended to build on his work by distinguishing conditions for damping.

Specifically, Gardner objects to the guidance on what to do when there is an inconsistency between short- and long-term trends (3.3.4). He correctly notes that there is no comparative research on this guideline. The guidelines were, however, developed as logical deductions from the Golden Rule. The reasoning behind guideline 3.3.4 is that a long time-series contains information not only on the recent trend, but also on cumulative knowledge about the trend, and that cumulative knowledge should be taken into account when forecasting.

Gardner also has reservations about the guideline that advises being conservative when the forecast horizon is longer than the historical data series (3.3.3). There was evidence from only one comparative study, although the logic seems compelling. Surely, for example, one should have little confidence in a 50-year-ahead forecast of dramatic change that was based on only five years of data.

Finally, Gardner expresses reservations about adjustments based on expert knowledge of causal forces (3.3.2), which includes the contrary-series rule. In that case, the logical deduction of the guideline is supported by five comparative studies that found forecast error was reduced for both one-ahead and many-ahead forecasts by following the guideline; 31% overall.

Gardner's call for further research to define better the conditions under which damping is most effective is sensible. Nevertheless, waiting for more evidence before following the Golden Rule guidelines when making extrapolation forecasts is not justified. Logic and evidence suggest following the guidelines on extrapolation as currently described until further research suggests revisions.

6. Discussion: implementation of evidence-based methods

Each of the commentators raises the issue of implementation. Their concerns are reasonable. The implementation of available evidence-based methods in practice is a major problem for forecasting. To some extent, this may be due to ignorance of the evidence-based procedures. The problem is almost certainly due in large part to the folklore that experts are able to make good judgmental forecasts even, or especially, about complex and uncertain situations. Another reason is the political motivation to provide a forecast that will promote a decision that the forecaster or the client favors.

The implementation problem is especially serious for the public sector. Without the discipline of competition and market prices, public sector forecasting is particularly vulnerable to bias in the direction of wish fulfillment. As a consequence, citizens and firms are exposed to the risk of major losses due to poor forecasting of government spending programs, taxation, subsidies, pension payments, provision of services, regulations, and wars. To counter the incentives to bias forecasts, governments should require public policy forecasters to follow the Golden Rule. For example, if governments follow the guideline to provide full disclosure (1.3), the media and public interest groups will be empowered to scrutinize and critique government forecasts using the Golden Rule checklist.

Another barrier to following the Golden Rule is the so-called precautionary principle. The precautionary principle implies that forecasting has no role when the situation is highly uncertain and it is easy to imagine catastrophic outcomes. The call is thus: Take action now; the apocalypse might happen, so scientific forecasts do not apply. That view brings to mind the slogan on the Ministry of Truth building in George Orwell's 1984: "Ignorance is strength."

The argument behind the precautionary principle confuses forecasting with decision-making and planning. The forecaster's role is to provide accurate unbiased forecasts about the likelihood and effects of alternative events, and the effects of alternative actions, including doing nothing. Accordingly, *forecasters* should rely on the Golden Rule. *Decision makers* should use the forecasts in cost and benefit analyses, and then decide on appropriate plans and actions.

The precautionary principle is illogical. For example, either extreme global warming or extreme global cooling might have disastrous effects. Since each is possible, the precautionary principle should require action to prevent both warming and cooling—efforts that would work against each other if they worked at all. Extreme warming and extreme cooling might each benefit many people; what the precautionary principle has to say on that point is not clear. The precautionary principle is popular among interest groups, who can propose potential catastrophes to suit their objectives, and politicians, who benefit from being seen to do something. People are susceptible to being swayed by appeals to the precautionary principle when they believe that other people will or should pay the cost of the proposed precautions. In such situations, people typically ignore probabilities, as was shown in experiments by Sunstein and Zeckhauser (2011). As S&H noted, the way that forecasts are presented can have a strong influence on how they are used.

Another issue with implementation is that statisticians are often unaware of the evidence underlying the Golden Rule and propose forecasting methods—such as data mining and step-wise regression—that violate the Golden Rule. Clients who are interested in accurate and unbiased forecasts can refer their forecasters to the Golden Rule checklist at GoldenRuleofForecasting.com before they start their forecasting efforts, and ask them to follow the guidelines.

The implementation of evidence-based procedures would probably be enhanced if there were penalties for failures to use proper procedures. Lawyers should use the Golden Rule checklist for cases where inaccurate forecasts have led to harm. By following the Golden Rule, experts should adhere to the same forecasting procedures no matter which side they represent. Since forecasts are always subject to uncertainty, the relevant test is whether the forecasters followed proper procedures.

Another way to encourage the use of the Golden Rule is to include the guidelines in forecasting software programs in the form of default options. The software could report instances where the user overrides the guidelines.

7. Conclusions

Logic and the empirical evidence to date support the Golden Rule of Forecasting's status as a general rule. The Rule is consistent with evidence from all areas of forecasting, and it applies across all fields and forecasting methods. That knowledge was used to develop the Golden Rule checklist.

The Golden Rule is the antithesis of common antiscientific claims that scientific forecasting does not apply because "this situation is different" or because "the outcome might be catastrophic." These claims of exceptionality encourage forecasters to ignore cumulative knowledge in order to provide clients with forecasts that they prefer.

Further research to improve the Golden Rule checklist guidelines, identify new guidelines, and learn more about the effects of conditions is desirable. Also desirable is research on whether the Golden Rule applies to the estimation of uncertainty—e.g., the determination of prediction intervals.

Forecasters, their clients, watchdog organizations, researchers, and lawyers can all use the Golden Rule checklist to determine whether forecasts are unbiased and likely to be accurate. Firms can use the checklist to improve their forecasting to the benefit of their owners, suppliers, and customers; investors can do so for new business ventures; and interested parties and the media can use the checklist to assess public policies. While the commentators offer cautions and ideas for extensions, there is no need to wait for further research given the many benefits of following the Golden Rule, not least of which is that violating a single guideline in the checklist is likely to increase forecast error by 44%, or more than two-fifths on average.

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